



SOLAR ROCKS

Team Meeting – 11/13
Design Review Presentation

MEETING OVERVIEW

- System overview.
- Solar collection methods.
- Solar collection analysis.
- Heat exchanger overview and different types.
- Thermal storage analysis and progress.
- Conclusion.
- Discussion and questions.

SYSTEM OVERVIEW

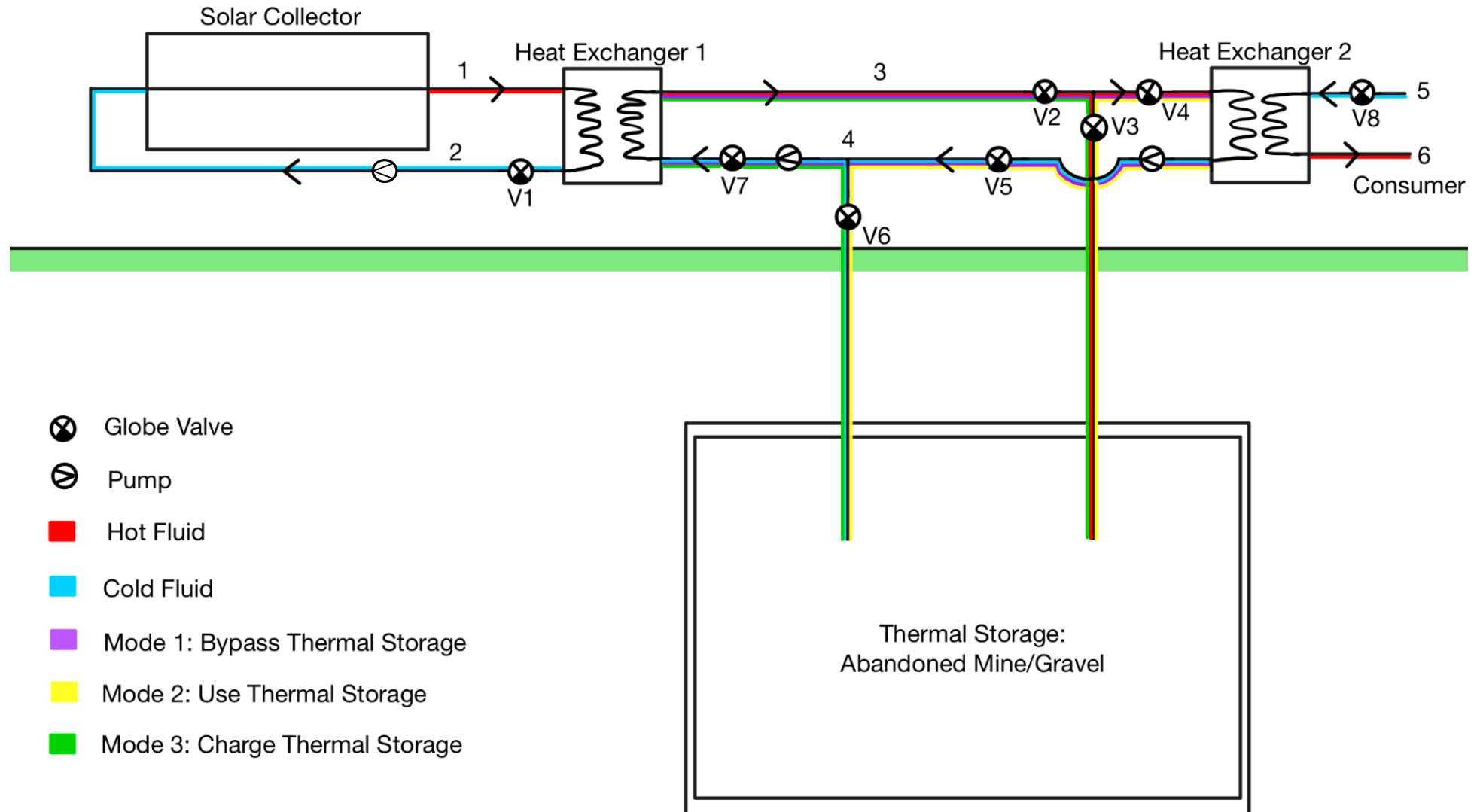


Figure 1

SYSTEM OVERVIEW

Mode	Valves Open	Valves Closed
Mode 1: Bypass Thermal Storage	V2, V4, V5, V7	V3 and V6
Mode 2: Use Thermal Storage	V3, V4, V5, V6	V2 and V7
Mode 3: Charge Thermal Storage	V2, V3, V6, V7	V4 and V5

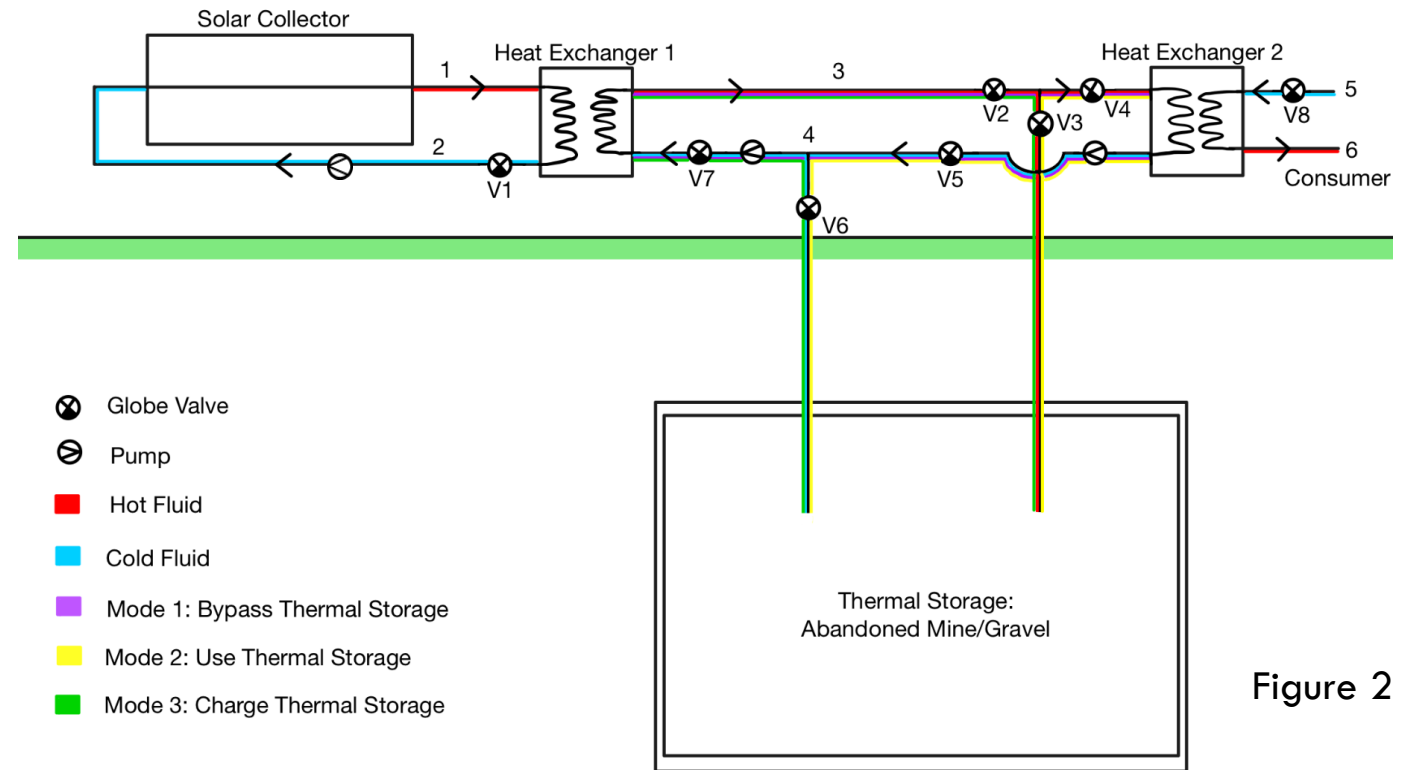


Figure 2

Required Materials:

- One solar collector - Two heat exchangers -Three pumps -Eight valves

SOLAR COLLECTION METHODS

SOLAR TROUGH

- Parabolic mirror bends light to a single focal point.
- Single axis tracking only.
- Have an efficiency of about 75%
- A single receiver tube is used.
- Commercial product we can purchase.
- Small scale model estimate was \$8,700

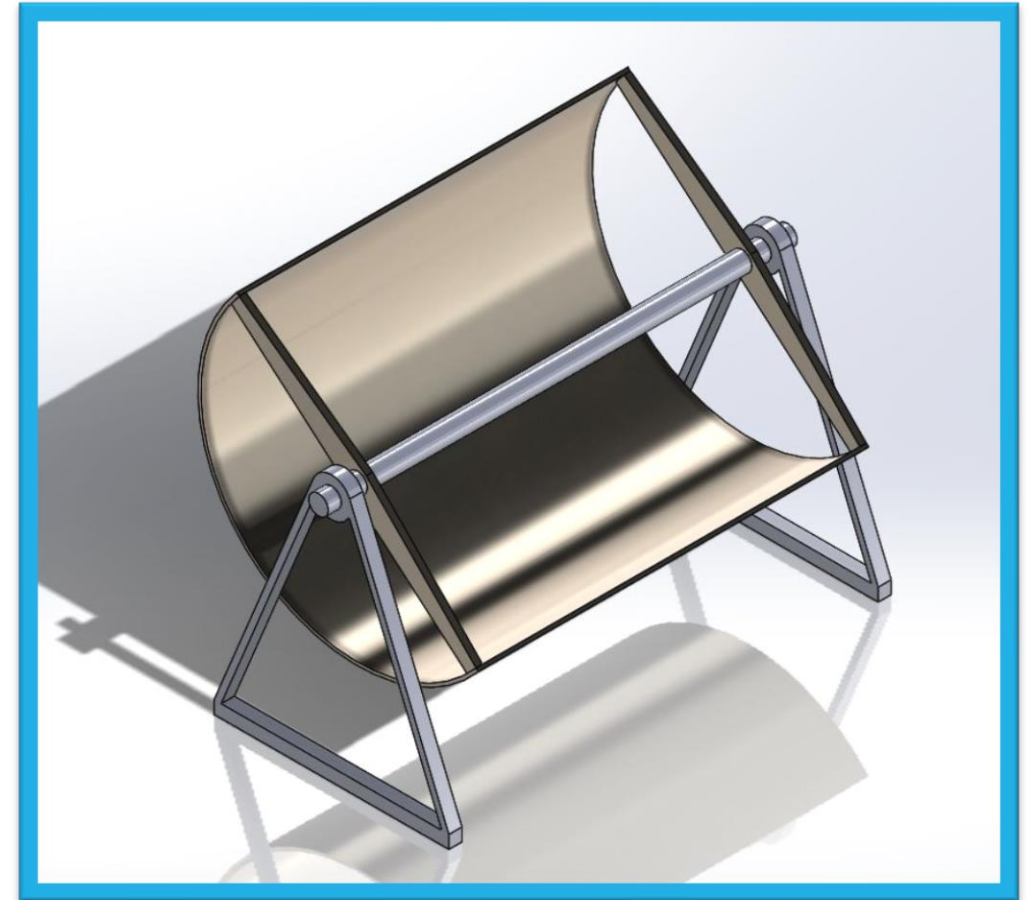


Figure 3.

SOLAR COLLECTION METHODS

COMPACT LINEAR FRESNEL REFLECTORS

- Array of flat mirrors acts like a Fresnel mirror on the ground.
- Multiple receiver tubes can be used.
- Commercial product we can purchase.
- Cheaper than a parabolic trough (generally).
- Have a product efficiency of roughly 65%
- Wider aperture can reflect more light.

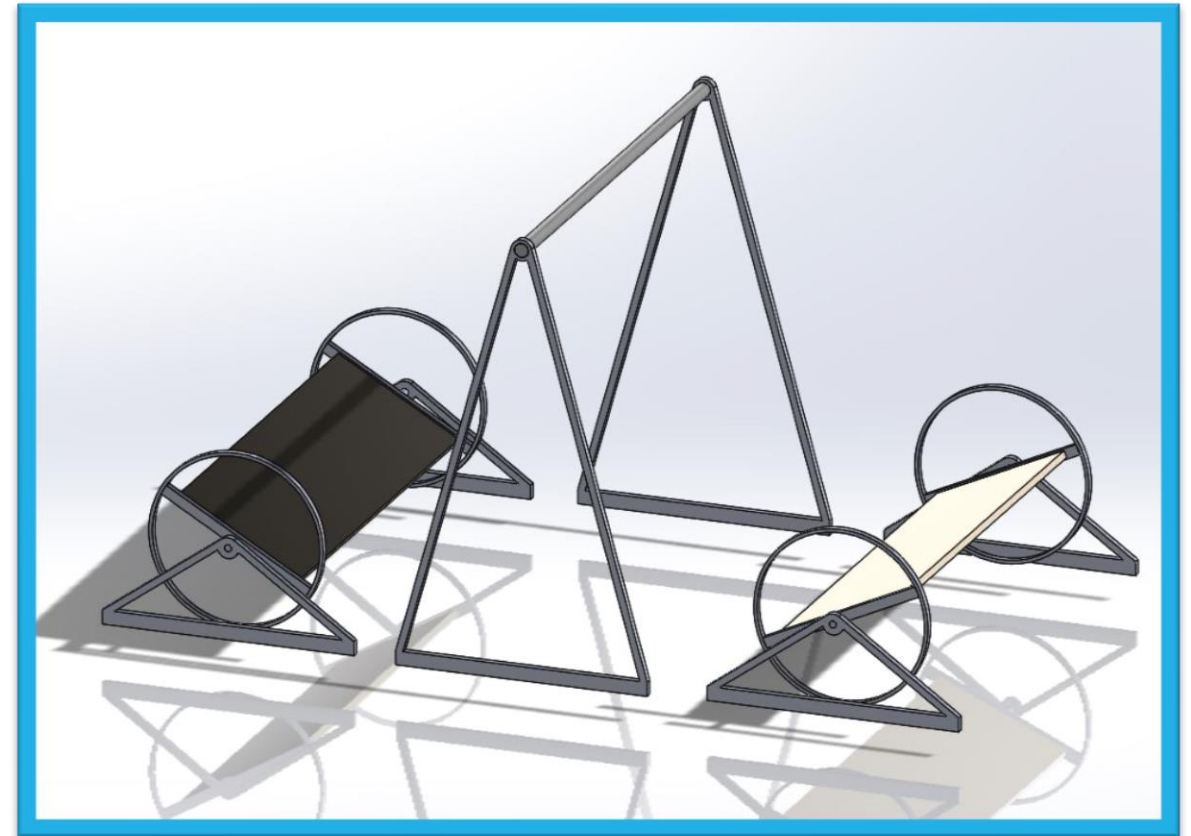


Figure 4.

	Solar Trough	Paraboloid Dish	Thermodynamic Panel
Cost	\$8700		\$2500-\$6000
Size	<ul style="list-style-type: none"> Torque Tube*: .1524m x 7.3142m Torque Tube Holders*: .0762m x .1524 m Surface Area: 5.75 m² 	<ul style="list-style-type: none"> Reflector Diameter: 9m Surface Area: 62 m² Mounting Post: 4.4m 	Each Panel 2m x .8m
Efficiency	75%	73%	
Solar Concentration		100	6 Panels- 7,500W
Installation Time	1 Week	8 hrs for 3 people	
Notes		<ul style="list-style-type: none"> 2 axis tracking Designed to operate in snow, ice, and wind 	<ul style="list-style-type: none"> Heat Water to 60C
Website	https://www.parabolicsolartrough.com/	http://www.solartronenergy.com/solar-concentrator/specifications/	http://www.energie.pt/en/solar-thermodynamic

Table 1.

POSSIBLE ALTERNATIVES

- Buy mirror or coating and build the rest of the system.
- Calculate the expected temperature output and use alternative heating method.

COMPARISON OF WORKING FLUIDS

	Water	Vegetable Oil	Therminol VP1	Ethylene Glycol	Solar Grade HTF	Sodium Potassium Salt
Freezing point (°C)	0	-11 to 20 (pour point)	12 (pour point)	-37	15	-12.6
Boiling point (°C)	100	250	257	107.2	400	785
Density (Kg/m ³)	997	915	1060	1113	1056	715
Specific heat capacity KJ/Kg-K	4.03	2.00	1.775	3.328	2.5	0.782
Viscosity (Pa.S)	0.001	0.0082	0.000985	0.00065	0.0002	0.00017
Cost (\$/Kg)	--	0.62	2.92	1	1.19	0.49

Table 2.

HEAT EXCHANGER OVERVIEW

- Necessary for separation of thermal storage from the rest of the system.
- Hot working fluid enters one side and heats the cold CO₂ on the other.
- Two different types widely used in industry.
 - Flat plate heat exchangers.
 - Shell and tube heat exchangers.

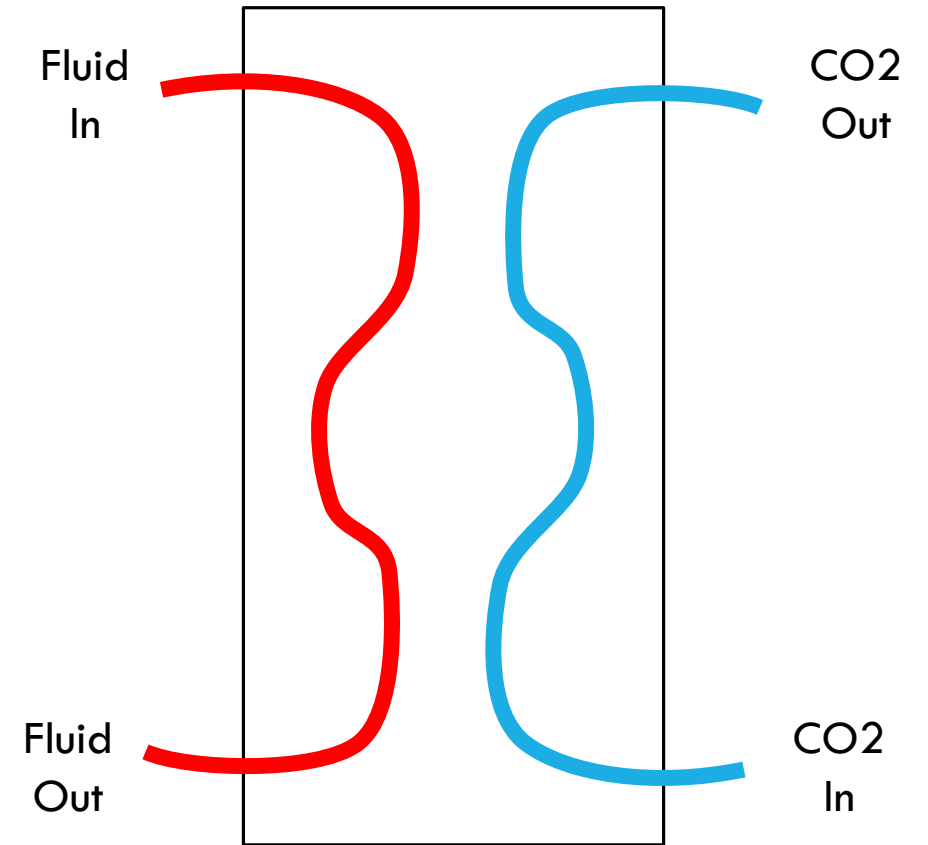


Figure 5.

HEAT EXCHANGER METHODS

SHELL AND TUBE HEAT EXCHANGERS

- Most widely used type of heat exchanger.
- Difficult to regularly clean.
- Maximum temperature of 300 °F
- Cost ~ \$1,000 - \$3,000.



Shell and tube heat exchanger source

Figure 6.

HEAT TRANSFER METHODS

FLAT PLATE HEAT EXCHANGERS

- More efficient than shell and tube heat exchangers.
- Maximum temperature of 300-450 °F
- Cost roughly \$500 - \$5,000.
- Easier to clean and maintain (gasketed plates).

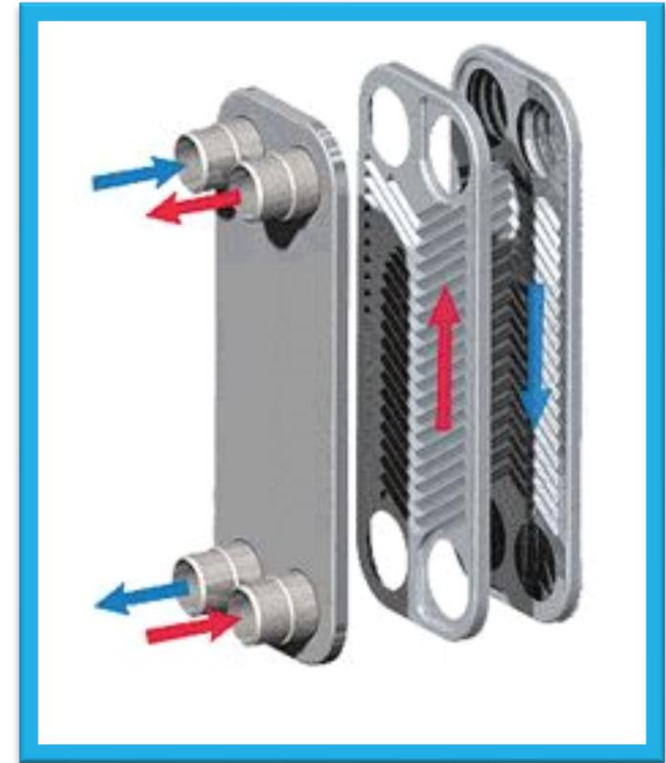


Figure 7.

<http://www.southwestthermal.com/brazed-plate-exchanger.html>

THERMAL STORAGE ANALYSIS

LUMPED CAPACITANCE APPROACH

Governing Equations:

$$\frac{T - T_{\infty}}{T_i - T_{\infty}} = e^{-\frac{hA_S t}{\rho V c}}$$

$$\tau = \frac{\rho V c}{h A_S}$$

$$Q = \rho V c \theta_i \left[1 - e^{-\frac{t}{\tau}} \right]$$

T	Temperature of the Spheres	V	Volume of the chamber
T _i	Initial sphere temperature	c	Specific heat of the fluid
T _∞	Temperature of the fluid in the chamber	t	Time that has passed
h	Heat transfer coefficient	τ	Thermal time constant
A _s	Surface are of the sphere	θ _i	Initial temperature Vs. Fluid Temperature
ρ	Density of the fluid		

Treat each sphere as an individual lump capacitance.

Break into sections of the chamber and numerically compute.

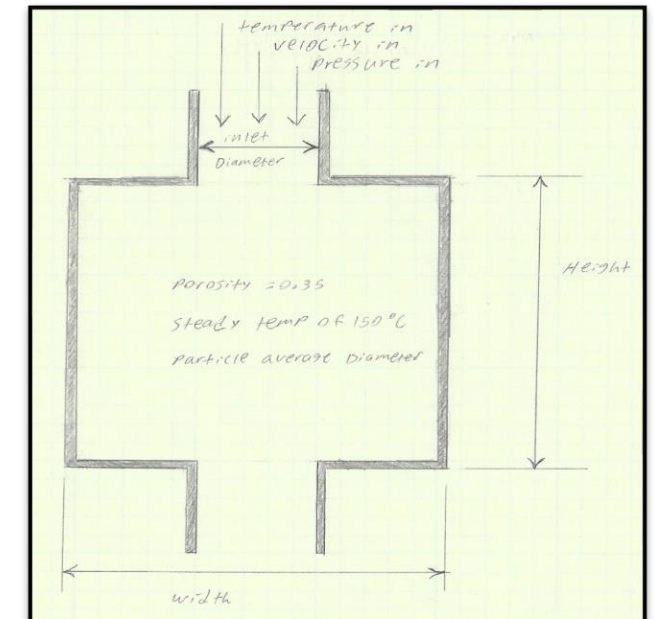


Figure 8.

CONCLUSIONS AND NEXT STEPS

- Project is currently on budget.
- Decision on project direction must be made.
- Specify and order materials for next semester assembly.



DISCUSSION AND QUESTIONS

BIBLIOGRAPHY

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Srivastva, U., Malhotra, R. K., & Kaushik, S. C. (2015). Recent Developments in Heat Transfer Fluids Used for Solar Thermal Energy Applications. Fundamentals of Renewable Energy and Applications. <https://doi.org/10.4172/20904541.1000189>